ECOSYSTEM RESTORATION
ALTERNATIVES DESIGN PAPER

TRUCKEE MEADOWS FLOOD DAMAGE REDUCTION AND ECOSYSTEM RESTORATION PROJECT
RENO / SPARKS, NEVADA

Prepared For

US ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Contract No. DACW05-01-0-0008
Delivery Order 2, Modification 4

Prepared By

MONTGOMERY WATSON HARZA
Sacramento, California

September 2002

TABLE OF CONTENTS

PAGE

LIST OF TABLES

PAGE

LIST OF PLATES

CHAPTER 1 - INTRODUCTION

A. PURPOSE AND SCOPE

The United States Army Corps of Engineers (USACE) is engaged in planning a flood damage reduction and ecosystem restoration project for the Truckee River in and near the Cities of Reno and Sparks, Nevada. As part of that planning, the USACE has requested the development of ecosystem restoration proposals for flood damage reduction alternatives along the river from Highway 395 to Interstate 80. At the present time, three flood damage reduction alternatives are under consideration. The USACE has requested that for each flood damage reduction alternative, three different levels of ecological restoration be evaluated. The levels would correspond to low, medium and high emphasis on restoration.

To develop restoration proposals for the alternatives several assumptions were made. The flood damage reduction alternatives are currently developed in a GIS format. The GIS data were used as the baseline for evaluating restoration possibilities. The flood damage reduction alternatives are conceptual and require further engineering design before their feasibility can be established. The assumption was made that additional design work may result in significant changes, to the degree that alternatives may be shifted spatially. Consequently, the feasibility of the restoration proposals that have been developed will require further assessment in relation to evolving flood damage reduction designs. Some, even many, of the impacts associated with existing plans could be avoided through design changes. Finally, in assessing the feasibility of some restoration measures, that is, in evaluating their likelihood of success and sustainability, the assumption was made that some alterations in river hydrology and management procedures can be implemented without jeopardizing the flood damage reduction mission. However, that issue has not been evaluated in detail here because of the conceptual nature of the alternatives. In the discussion that follows, some of the changes in flood damage reduction alternatives that might be necessary to accommodate restoration are discussed.

The proposals presented in this document were developed using a combination of existing published and unpublished data and reports and original field research. Although considered sound on the basis of this information, other data may come to light in future engineering and environmental studies that may have a bearing on restoration feasibility. To implement some of the more complicated restoration proposals additional design work will be necessary. In the closing section of this report, some of the additional work that will be necessary for further refinement of designs is described. Future restoration planning, design and implementation must be coordinated closely with future engineering and environmental work.

This work was conducted under contract #DACW05-01-0-0018, Delivery Order 2, Mod 4. It was done under the direction of James Sherar and Mary Paasch. Dr. Richard Harris was the principal investigator. Vinil Reddy and Michael Steffinger assisted in the field and with mapping.

B. STUDY AREA LOCATION

The Truckee River flood damage reduction and ecosystem restoration project area generally encompasses the river and nearby lands lying between Verdi, Nevada and Vista inclusive of the

Cities of Reno and Sparks. The study area for this restoration assessment focuses on the river corridor between the Highway 395 bridge in Reno and the Interstate 80 in Sparks. The project watershed is illustrated on Plate 1. In this report, the study area is described as four stream reaches: Reach 1 from Highway 395 bridge to Greg Street bridge, Reach 2 from Greg Street bridge to McCarran Boulevard bridge and Reaches 3 and 4 from McCarran Boulevard bridge to the vicinity of Interstate 80 (Vista).

C. STUDY AREA DESCRIPTION

There are several existing studies that describe riparian and geomorphic conditions within the study area. Available documents include a conceptual restoration plan (CH2M Hill, 2000), preliminary and final Habitat Evaluation Procedures reports (CH2M Hill, 2001) and a study on the geomorphology of the study area (Water Engineering and Technology Inc., 1990). Various unpublished USACE planning studies exist (CH2M Hill, 1999 and USACE, 2000). Recent and historic aerial photographs are also available from Washoe County and the USACE. Generally, the Truckee River within the study area has a relatively narrow riparian zone comprised of a willow shrub community and cottonwood riparian forest, sometimes juxtaposed or mixed. Forest cover is intermittent with few large patches.

Available evidence indicates that historically, the cover of riparian forest and herbaceous wetlands was more extensive in the Truckee Meadows area. However, in some locations, most notably Reach 1, the riparian zone was always rather narrow. Since the late 19th century many factors have contributed to a reduced area of riparian forest including agriculture, water diversions, channel incision and urban development.

Existing information was not considered adequate for restoration planning. Therefore, field investigations were undertaken in the project area during late July and August, 2002. The entire area was initially inspected on foot to select sites for more detailed study and to develop a field study plan. Subsequent to initial reconnaissance fieldwork was carried out with the following objectives:

- Determine stream bank conditions: stream banks throughout the study area were classified as fully vegetated (>50 percent cover), partially vegetated (<50 percent cover) or barren (with either natural substrate or artificial substrate). Streambank conditions were mapped on aerial photographs and verified in the field. In association with this, the areal extent of willow-dominated riparian vegetation was mapped.
- Determine locations and characteristics of residual riparian forest: stands (several trees), galleries (lines of trees) and groves (mappable patches) of residual riparian forest (usually cottonwood) were mapped on aerial photographs and verified in the field. Tree heights and diameters were measured and recorded but those data are not reported here. Minimum mapping units were less than an acre.
- Determine locations of riparian species regeneration: stream banks, attached bars, mid-channel bars and point bars were inspected to determine if riparian species regeneration was present. Site locations were recorded on aerial photographs in the field.

- Determine locations of exotic vegetation: occurrences of exotic trees and shrubs were recorded. Sources of exotic propagules (e.g., landscape plantings) were also identified and mapped in the field on aerial photographs. Substantive areas of exotic vegetation (>one acre) were mapped.

The following discussion describes the current conditions of each project reach within the study area.

1. Reach 1: Highway 395 to Greg Street Bridge

For most of the south side of this reach there is a narrow riparian zone (10 to 30 feet) that is confined by adjacent land uses. The south bank is bordered by the Hilton Hotel and recreational vehicle park between Glendale Avenue and Greg Street and by a correctional facility and light industrial development between Glendale and Highway 395. Much of the south bank is riprapped but there is abundant bank cover of willows and wild rose throughout. There is only one area of completely barren bank on the south side of the river.

On the north bank, there is considerably more open land adjacent to the stream but the riparian zone is still confined to the immediate area of the channel. The stream bank is partly riprapped and there is more barren bank. Nearly the entire length of stream from Glendale to Highway 395 (Fisherman's Park) has a very narrow and discontinuous riparian zone bordered by a steep slope.

There are patches of residual riparian forest and individual cottonwood trees throughout this reach on both sides of the river. However, there are many exotic trees present that sometimes dominate the streamside forest. Where exotic trees were dominant, the forest was not mapped. Cottonwood and willow regeneration is also common, especially above and just below the Glendale Bridge where the floodplain widens and mid-channel bars are present. The main exotic woody species is elm, which is present throughout the reach. Other exotics include blackberry and tree of heaven. There are no large, contiguous patches of exotic vegetation. Rather, the entire reach has exotics scattered throughout the riparian zone.

The planform geomorphology of the stream is relatively fixed in this reach due to extensive revetment. The channel is coarse-grained and steep and there is minimal bank erosion. Base control is maintained by two diversion structures and there are intermittent bars (Water Engineering and Technology, Inc., 1990). Existing information on substrate indicates that there is a foundation of cobbles and boulders within a gravel and sand matrix. There is little fine textured substrate in this reach (unpublished file data).

Existing restoration opportunities in this reach include increasing bank cover of native riparian species (mainly willow and wild rose), enlarging the riparian zone on vacant land on the north side of the river throughout the reach, enlarging the riparian zone in the vicinity of Glendale Bridge and controlling exotics.

2. Reach 2: Greg Street Bridge to McCarran Boulevard Bridge

For descriptive purposes, Reach 2 can be subdivided into two sub-reaches, the first between Greg Street and Rock Boulevard and the second between Rock Boulevard and McCarran Boulevard. The south side of the river between Greg and Rock is entirely vacant land, some of which is currently being used as a dumpsite. Bank cover is nearly continuous willow. There are residual patches and scattered individual large cottonwood present on the south side. There is also continuous riparian vegetation along the Pioneer Ditch on the south side of the river.

On the north side of the river there is vacant or park land immediately downstream from Greg Street with continuous bank cover of willow and a streamside gallery of residual cottonwoods. Further downstream, there is a trailer park. The bank there has been riprapped and is partly to fully vegetated with willows, but the width of the willow community is narrow (<20 feet). The trailer park has been landscaped with honey locust and other exotics that have migrated into the riparian zone. Between the trailer park and Rock Boulevard there is a linear park that has residual cottonwoods in groves and as individual trees with an understory of turf. This park has been extensively planted with trees exotic to the site, including giant sequoia.

The sub-reach between Rock and McCarran generally has the best riparian conditions in the entire study area. There are two relatively large riparian patches on point bars on the south side of the river. These consist of dense willow shrub cover on the lower parts of the bars and a canopy of large cottonwoods at the backs of the bars. Exotic trees are also present. Development on the south side of the river is relatively limited.

The north side of the sub-reach between Rock and McCarran has been developed nearly throughout but there are still scattered large cottonwoods and a few cottonwood patches. About midway through this sub-reach there is a point bar, which is bisected by the levee-trail leaving a relatively large residual patch of large cottonwoods on the landward side of the levee. Dead cottonwoods and stumps in the upstream part of this area indicate that at one time, it was a larger patch. There is also a park on the north side of the river with residual cottonwoods. Near McCarran there is an incursion of tree-of-heaven that has established in the riparian zone. Otherwise, as in Reach 1 and the upstream section of Reach 2, exotics in the riparian zone mainly consist of scattered individual planted or volunteer landscape trees (oaks, sycamore, ash, elm, Russian olive, and giant sequoia).

Like Reach 1, this reach is also characterized by a relatively fixed stream planform but unlike Reach 1, there is considerable sediment storage in bars. The bars are scaled to two different discharges. Bank-attached bars are subject to extensive re-working and rearrangement in space during peak flows. Judging from the presence of abundant willow and cottonwood regeneration on them, they have been stable for at least a few years. Point bars are higher flow features that aggrade during peak flows. Point bars are limited in terms of downstream translation and lateral growth. They have high relief, rather than gradual slopes. The present distribution of sediments in low bars generally reflects the most recent mobilizing flood while the point bars are locked into positions. This can be observed in mapping of the channel from 1946-89 (Water Engineering and Technology, Inc., 1990). The channel widened and became less complex but the planform did not substantially change. The aggradation above McCarran may have been triggered by upstream channel improvements in the early 1960's. Those improvements included

removal of obstructing boulders and bars and that appeared to aggravate a natural tendency to aggrade in Reach 2 (widening reduced transport capacity). Substrate in this reach consists of silty sand to sandy silt from 2-20 feet deep with coarse materials below (unpublished file data).

Restoration opportunities in this reach are extensive, especially on the south side of the river where there is considerable vacant land. Riparian forest could be expanded on point bars, bank cover could be increased, residual riparian forest could be reconnected to the stream and exotics could be controlled.

3. Reaches 3 and 4: McCarran Boulevard Bridge to Interstate 80

The south side of the river in this reach is undeveloped and traverses land used for agriculture by the University of Nevada. There are some residual patches and galleries of riparian forest in the upstream area, but trees become rare with distance downstream. Some large cottonwood trees are being undermined by bank erosion. Bank conditions on the south bank deteriorate with distance downstream and there are frequent gaps in riparian cover. From about the Steamboat Creek confluence to the end of the reach bank vegetation is almost exclusively exotic white top. The stream is incised, bank erosion is common and generally, riparian bank vegetation is limited or comprised of exotics.

The north side of this reach is almost entirely developed with industrial uses with the exception of a vacant parcel just upstream from the North Truckee Drain. Bank conditions on the north side are variable. There are some patches of residual riparian forest on the north side of the river that are mainly on the landward side of the levee-foot path. Otherwise, residual riparian trees are relatively uncommon on the north side of the river in this reach. Cottonwood regeneration is abundant on bars and islands just downstream of McCarran Boulevard bridge.

The extent of exotic vegetation increases with distance downstream. White top was first noted in this reach about one half mile downstream from McCarran Boulevard. It has invaded the willow community upstream of the North Truckee drain and altogether dominates the adjacent terrace in the vicinity of Steamboat Creek. It dominates the bank cover on the north bank for most of the distance between Steamboat Creek and Interstate 80.

Below McCarran Boulevard the frequency of instream bar deposits decreases due to steeper channel slope. Channel incision becomes prominent, headcuts appear and bank failures become common. As of 1989, the channel had incised at least seven feet (Water Engineering and Technology, Inc., 1990). It has probably incised further since then, especially in response to the 1997 flood event. Lateral widening is now occurring due to bank erosion. Incision has reached underlying Tahoe outwash deposits, which may slow it some. The causes for incision appear to be complex and may include modifications to base level controls, channel improvements, presence of dams in the upper watershed and downstream, land uses and steepened channel slope due to straightening (Water Engineering and Technology, Inc., 1990). Substrate in this reach consists of 12-25 foot deep clay overlying outwash (unpublished file data).

The restoration possibilities in this reach are probably best in the area immediately downstream from McCarran Boulevard Bridge. Those include rehabilitating and extending existing riparian forest; controlling exotics that are present; reconnecting residual riparian patches with the stream

and increasing stream bank cover. Downstream degradation is severe and possibly irreversible without extensive measures to improve geomorphic conditions, rehabilitate banks and control exotics. There is suitable land for restoration, however, on the south side of river.

4. Summary

The project area is a mosaic of degraded ecological conditions, remnants of riparian forest and lands recovering from past impacts. Degradation is most severe in the downstream reach due to a combination of unstable geomorphology and exotic species invasion. Conditions are best in the middle reach. The stream as a whole is in a process of adjusting or recovering from past channelization and other changes in the watershed. Recovery is indicated by regeneration of native riparian species on bars and armored banks and elsewhere throughout the study area.

There are several aspects to the existing conditions that must be considered in any restoration planning. First, there is the very unstable geomorphology that is associated with Reaches 2 and 3. Reach 2 is aggraded and limited in its ability to transport sediment. Consequently, lower floodplain deposits that serve as sites for riparian regeneration are not stable. Reaches 3 and 4 may still be incising and is eroding. As it incises, the connectivity between the stream and its floodplain(s) further deteriorates. Incision may have already helped to facilitate invasion of white top to the detriment of native riparian species (S. Swanson, pers. comm.). These problems are not local but reflect watershed-wide conditions. Unstable geomorphic conditions and degradation is also evident downstream all the way to Pyramid Lake (A. Padilla, pers. comm.). To solve these problems and thereby facilitate restoration, a watershed-wide approach or evaluation will be needed.

Second, there is the presence of existing riparian vegetation, which is both serving to stabilize banks as well as providing habitat values. Especially in Reaches 1 and 2 and in the upstream part of Reaches 3 and 4, native riparian bank vegetation is relatively abundant and is successfully establishing on artificial substrates. There is still a significant amount of riparian forest remaining in the study area that could serve as nuclei for restoration efforts. Avoiding removal of this vegetation should be a major concern.

Third, there is the problem of exotic species in the study area. This includes not only the obvious ones, like white top, but the multitude of exotic trees and shrubs that are slowly but surely replacing the native species. In many urban stream corridors exotics dominate riparian zones entirely. That is not yet the case in Truckee Meadows but it could happen in the future. Controlling exotics may or may not be a priority in restoring the riparian zone. If it were a priority, a major effort with some short-term impacts would be necessary. For example, many trees next to the stream are exotics and their removal would have significant local effects. Attempting to control white top would mean extensive clearing on banks.

Finally, there is the possibility that restoration efforts may not be compatible with present and future uses occurring in and near the riparian zone. Although not evaluated in detail in the fieldwork, at the present time, industrial and recreational uses are having localized impacts. These include vegetation clearing for various reasons (usually for safety or hazard abatement), bank erosion due to concentrated pedestrian or vehicle access to the stream, and soil compaction.

They also include planting of exotics, irrigation and fertilization. The success of a restoration effort based on protecting, re-creating and expanding natural riparian communities will depend on the degree to which users understand and support the effort. It will also depend on fundamental land use planning decisions in the stream corridor.

CHAPTER 2 - FLOOD DAMAGE REDUCTION ALTERNATIVES

The flood damage alternatives under consideration for Truckee Meadows conceptually differ in one major way. Two alternatives propose a combination of levees and floodwalls to contain, detain, and convey floodwaters for the entire stream between Highway 395 to downstream of Steamboat Creek. They would do little or no direct work within the existing channel. They differ from each other mainly in that one provides off-stream detention to mitigate downstream impacts. A third alternative, called the "Community Coalition Alternative" proposes to modify the existing channel between Greg Street and Interstate 80 to create capacity adequate for conveying flood waters. Channel modifications are referred to as "benching", as described below:

"This measure involves excavating a benched area on the south (right) bank of the Truckee River, up to 200 feet wide from the channel centerline. Vertically, the excavation would extend down to a level corresponding to the water surface elevation (WSE) associated with the two-year flow under existing conditions. (The two-year flow is the maximum discharge one would expect to see once within a two-year period. The two-year flow has a 50 percent probability of occurring in any given year). Since this level is significantly above that which occurs throughout most of the year, excavation to the two year WSE would create a bench or terrace of land above the channel bed, which would be inundated during high flow events. The measure would be intended to increase the high flow channel capacity and thereby potentially reduce water surface elevations in the Truckee Meadows area during a flood."

Modifications to the benching proposal have occurred since the above statement was written in USACE planning documents. Currently, the concept is to create two benches, a higher and a lower one within a 350 foot-wide area from Greg Street to beyond Steamboat Creek confluence. The elevation of the lower bench would remain at the two-year flow level. Another bench would be approximately two feet above the lower one. The proportions of low versus high bench would vary by reach. From Greg Street to McCarran Boulevard, the channel would be 70 percent low bench and 30 percent high bench. Downsteam from McCarran, the proportions of low versus high bench would be reversed (P. Urban, pers. comm.). Excavating the enlarged channel on the south side of the river would entirely replace the existing bank from Greg to McCarran. There would however, be some possibilities for adjusting the design to avoid significant riparian vegetation or other resources (P. Urban, pers. comm.).

Because of these distinct differences between the alternatives, there are also quite different possibilities for riparian restoration. Some of the concepts for restoration that have been proposed in USACE planning documents would apply to any alternative, others would have to be adjusted or modified for the selected alternative.

CHAPTER 3 - ECOLOGICAL RESTORATION POLICIES AND OBJECTIVES

This report provides ecological restoration measures and proposals that are consistent with Corps policy and existing planning direction for Truckee Meadows Flood Damage Reduction and Ecosystem Restoration Project. The following discussion summarizes published and unpublished policy and planning direction pertaining to the proposed project. These documents include the Corps planning manual, which provides the general principles for planning ecological restoration projects. Existing project background reports were used to identify specific ecological restoration proposals that have already been formulated for Truckee Meadows project area. The results of this review are presented below.

A. GENERAL POLICY

- The USACE planning manual (USACE, unpublished) provides policy direction for ecological restoration projects. According to the USACE manual,
  - The focus of (ecological restoration) projects…is the restoration of ecosystems and ecological resources and not restoration of cultural and historic resources, aesthetic resources, or cleanup of hazardous and toxic wastes.
- General objectives for ecological restoration projects are described,
  - The objective of Civil Works ecosystem restoration is to restore degraded significant ecosystem structure, function, and dynamic processes to a less degraded, more natural condition….Restored ecosystems should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology….Those restoration opportunities that are associated with wetlands, riparian and other floodplain and aquatic systems are most appropriate for USACE involvement….
- Protection may be included as part of Civil Works ecosystem restoration initiatives, when such measures involve efforts to prevent future degradation of elements of an ecosystem's structure and functions….
  - Land acquisition in ecosystem restoration plans must be kept to a minimum.
- With regard to projects that involve both ecological restoration and recreation facilities, USACE policy states,
  - It is important that proposed recreation features are appropriate in scope and scale to the opportunity provided by ecosystem restoration projects, and that the recreation development and anticipated use be compatible with the ecosystem restoration purpose of the project. The recreation potential may be satisfied only to the extent that recreation does not significantly diminish the ecosystem outputs that justify the ecosystem restoration project.
- USACE policy advocates a watershed perspective when planning ecological restoration projects,
  - Ecosystem restoration projects that are conceived as part of a watershed planning initiative or other regional resources management strategy are likely to more effectively meet ecosystem management goals than those projects and decisions developed

independently… Not all restoration studies will be "watershed studies," but all USACE studies should have a watershed perspective.

- With regard to prioritizing restoration, "USACE planners can consider a potential restoration site that has declining trends and an imperiled status to be more significant than one that is recovering. Planners should also consider the "recoverability" (i.e., the ability of human intervention to restore the natural productivity or condition of the ecosystem) of a degraded resource in examining a resource's status and trends."
- Examples of USACE ecological restoration activities include… "restoration alternatives that serve to improve connectivity by creating or re-establishing habitat corridors; eliminating or addressing the pattern of fragmentation; or removing barriers, such as dams and other water blockages, that disrupt otherwise contiguous habitats."
- When screening ecological restoration alternatives, the USACE uses the criteria of acceptability, completeness, effectiveness and efficiency, described as follows:
  - An ecosystem restoration plan should be acceptable to State and Federal resource agencies, and local government. There should be evidence of broad-based public consensus and support for the plan… this does not mean that the recommended plan must be the locally preferred plan."
- A plan must provide and account for all necessary investments or other actions needed to ensure the realization of the planned restoration outputs…. Where there is uncertainty concerning the functioning of certain restoration features and an adaptive management plan has been proposed it must be accounted for in the plan.
- An ecosystem restoration plan must represent a cost-effective means of addressing the restoration problem or opportunity.
- An ecosystem restoration plan must make a significant contribution to addressing the specified restoration problems or opportunities (i.e., restore important ecosystem structure or function to some meaningful degree)."
- Finally, some of the types of improvements that USACE planners may advocate include,
  - "use of dredged material to restore wetlands, restoring floodplain function by reconnection of oxbows to the main channel, providing for more natural channel conditions including restoration of riparian vegetation, pools and riffles and adding structures, modification of obstructions to fish passage including dam removal, modifications to dams to improve dissolved oxygen levels or temperature downstream, removal of drainage structures and or levees to restore wetland hydrology, and restoring conditions conducive to native aquatic and riparian vegetation."

B. OPERATIONAL DEFINITIONS

The following principles have been extracted from USACE policy to help guide the inventory, analysis, and planning processes:

- Restoration should aim to restore degraded ecosystems to less degraded, more natural conditions.

- Restoration can include protection to prevent future degradation.
- Land acquisition should be minimized (i.e., restoration should be confined to project boundaries).
- Recreational development should not diminish restoration outputs.
- Recovering ecosystems have a lower priority for restoration than ecosystems that are on a trajectory of further degradation.
- A watershed-wide perspective should be used to develop restoration plans.

C. SPECIFIC OBJECTIVES FOR THE STUDY AREA

The USACE has stated a range of restoration objectives in its background project planning documents. Many of these objectives pertain to riparian restoration. They include:

General Principles:
- Promote a *living river* concept by preserving and enhancing fish and wildlife habitat, water quality, and natural geomorphic characteristics of the River, and restore environmental resources consistent with the flood damage reduction objective.

Related Objectives:
- Maximize future restoration opportunities.
- Create wetlands and floodplain riparian terraces to maximize riverine fish and wildlife habitat.
- Weave terraces/overflow channels through the greenbelt corridor.
- Re-establish a more natural river floodplain.
- Improve water quality through development of wetlands.
- Arrest erosion of banks and berms at sites along the Truckee River.
- Allow migration of terrestrial and aquatic species, especially the passage of fish.
- Modify near stream land use, instream, and flood control activities to reduce disturbance of riparian corridor.
- When possible, set aside the low floodplain as open space.
- Fill gaps in riparian forest caused by flow modifications.
- Maximize the value of existing habitats of fair and good quality.
- Set levees and floodwalls back from existing habitat and vegetation.

The USACE has identified a number of environmental constraints to achieving these (and other) objectives including:
- Project operation and maintenance practices, including debris management, should be environmentally sensitive.

- Maintain water table necessary to sustain vegetation.
- Preserve existing vegetation.
- Utilize bio-technical and habitat-friendly riverbank treatments.
- Preserve archeological resources.
- No net loss of aquatic or riparian habitat.
- Ensure that the project design, construction, and operation does not:
  - Increase waterborne concentrations of nutrients, turbidity, toxic pollutants, or total dissolved solids,
  - Increase discharge of untreated urban runoff,
  - Increase potential for hazardous material to enter the river,
  - Increase river temperatures, or
  - Decrease dissolved oxygen.
- Impacts downstream of the study area should be avoided, or, if any, mitigated. Downstream impacts to avoid include:
  - Increasing downstream flood flows and water surface elevations,
  - Inducing or exacerbating erosion, and
  - Negatively impacting Lahontan cutthroat trout, cui-ui, and their habitats, and damaging other aquatic or riparian habitat.

D. COMMUNITY COALITION OBJECTIVES

In addition to the above objectives, the Community Coalition Alternative and related background information (Maser, E., 2002) identify additional restoration objectives:

- Develop an integrated hydraulics, water quality, geomorphologic hydrodynamic model to confirm the effects of proposed channel modifications.
- Floodplain preservation first and structural solutions last. Save the beauty of the Truckee River. Don't forget the fish.
- Reserving the floodplain for the river is the best way to prevent flood damages. Policies are needed to slow and eventually stop the loss of the remaining floodplain.
- We can enhance the beauty of the Truckee River and provide flood protection, by broadening the natural river corridor-meaning giving the river channel more capacity to hold water during floods, and developing the channel-way with cottonwoods, parks and paths for public enjoyment.
- Improve water quality by restoring riparian vegetation and allowing the river channel to meander and be composed of natural gravels and silts that form the riffles and pools needed by fish.

The main way in which the Community Coalition expects to achieve these objectives is by constructing floodplains (at two elevations) between Greg Street Bridge and Interstate 80.

E. SPECIFIC PROJECT RESTORATION PROPOSALS

Existing planning documents contain specific restoration proposals for the study area. These may apply directly to any alternative or they may be modified or adjusted to work with a selected alternative. All of the ones discussed below have been carried forward for further analysis and decision making by the USACE. These proposals were taken into consideration in the assessment of conditions in the study area and developing restoration measures (Chapter 4).

1. Highway 395 to Greg Street

This measure consists of enhancing riparian habitat, creating new riparian habitat and augmenting riparian areas with riparian transition vegetation from Highway 395 to Greg Street along both banks of the river. Upstream from Glendale Avenue existing riparian habitat on the north bank of the river would be enhanced by planting additional tress and shrubs among the existing vegetation and extending the riparian habitat upslope with additional plantings. Riparian transition zone plant species would be used to extend the riparian corridor to the bike path next to Galletti Road. Downstream of Glendale Avenue, restoration actions would be conducted on both sides of the river. Riparian species would be planted among the existing vegetation to create a continuous band of vegetation about 50 feet wide. On the south side of the river between Glendale Avenue and Greg Street, the existing riparian vegetation would be enhanced by planting riparian trees and shrubs among the existing vegetation as on the north bank of the river. Adjacent to the Hilton Hotel parking lot additional cottonwoods, willows, alders and other riparian species would be planted.

2. Greg Street to McCarran Boulevard

On the south side of the river, the potential for setback levees (under some alternatives) provides considerable space for habitat restoration. Like the I-395 to Greg Street measure, this measure would consist of enhancing riparian vegetation, creating additional riparian vegetation and creating riparian transition zone habitat. Restoration on the south side of the river would be more extensive than on the north bank. On the north side of the river, restoration would primarily be limited to enhancing existing vegetation.

3. McCarran Boulevard to Steamboat Creek

Two (now one, the Community Coalition Alternative) of the flood control measures under consideration include widening the Truckee River channel on the south side between McCarran Boulevard and Steamboat Creek to increase channel capacity. This restoration measure includes creating riparian habitat between McCarran Boulevard and Steamboat Creek in the proposed widened channel. If channel widening were not included in the selected plan, this measure would

be modified to retain existing vegetation. The end result for either scenario would be the creation of a similar amount of riparian habitat.

In addition to habitat restoration on the mainstem Truckee River, a wetland complex would be created between Steamboat Creek and the Truckee River. The Steamboat Creek channel would be relocated to the west and would provide water to a newly created emergent wetland complex adjacent to the new channel's west bank. Riparian trees and shrubs would be planted adjacent to the wetland margins and the new Steamboat Creek channel. Riparian species would be planted along the western edge of the wetland complex, between the wetland complex and the new Steamboat Creek channel, and along the eastern edge of the new Steamboat Creek channel.

4. Other Restoration Proposals

USACE planning documents include several other restoration proposals that might be included in one or more alternatives. Ones within the project study area include floodplain restoration in the University farms and Edison areas. Use of bioengineering approaches to bank stabilization, including replacement of riprap with bioengineering structures is also proposed.

CHAPTER 4 - ECOSYSTEM RESTORATION MEASURES

Ecosystem restoration measures were developed on the basis of field studies, professional judgment, USACE ecological restoration policies and objectives and project planning documents. These have been developed at the stream reach level, recognizing that conditions in the entire watershed will need to be evaluated further during future design phases. Three levels of restoration emphasis are presented. These may be applied to any of the flood damage reduction alternatives. The primary differences between alternatives would be in the amount of area subjected to restoration. The restoration measures are applied to each project reach in Chapter 5.

A. STREAM BANKS

Stream bank conditions affect the sediment supply available to the river, planform stability (i.e., rates of meandering and lateral channel migration) and flood flow velocities. Stream bank overhang is an important component of aquatic habitat as well. Stream bank conditions also have an effect on the establishment and growth of riparian vegetation. Substrate on the stream bank as well as bank angle determine whether or not riparian vegetation can establish easily or not. Generally, the steeper the bank and the harder the substrate the more difficult the bank is to revegetate.

As a rule, it is desirable that stream banks have as much riparian cover as is possible to reduce accelerated erosion, enhance fish and wildlife habitat and maximize bank stability. Riparian bank cover will not prevent natural lateral migration or reduce meander rates but it will prevent chronic accelerated erosion caused by human impacts. Riparian vegetation on channel banks can reduce the capacity of a channel to convey floodwaters. In the Truckee Meadows area, natural stream bank cover generally consists of shrubby willows and wild rose, although cottonwoods, tree willow and exotic trees and shrubs may be present. Three emphasis levels of stream bank restoration would be:

- Low: allow riparian vegetation to naturally establish and grow on natural or artificial banks wherever possible. Take no steps to remove it. Actively manage natural regeneration by controlling competition, thinning where appropriate and other cultural treatments, including irrigation. Use bioengineering approaches for new bank stabilization projects. A variant on the low restoration emphasis applicable to the Community Coalition Alternative would be to apply erosion control to banks created by benching. This would include hydroseeding with native seed mixes or similar measures.
- Medium: in addition to the above, selectively remove existing artificial bank stabilizing materials to open up new sites for natural and artificial regeneration of riparian species. This may include re-shaping some banks where necessary to reduce bank angle. Plant as necessary to supplement natural regeneration. There is no medium emphasis for bank treatment in the Community Coalition Alternative.
- High: remove all artificial bank stabilizing materials that are barren, re-shape banks as necessary and use bioengineering practices and planting to increase riparian cover. For the

Community Coalition Alternative a high emphasis would entail application of bioengineering structures to all newly created banks.

In any of these stream bank restoration measures it is assumed that the existing level of riparian bank cover would be maintained with one or more of the flood damage reduction alternatives. It is further assumed that removing artificial bank stabilization that is being successfully revegetated with native vegetation (i.e., that is recovering) would not be prudent.

For purposes of quantifying habitat units, changes in stream bank cover would generally correspond to changes in the willow habitat type (CH2M Hill, 2001).

B. RIPARIAN FOREST

Natural riparian forest provides a wide variety of ecological and geomorphic functions. It includes a tree component consisting of one to several canopy layers. In the Truckee Meadows area, riparian forest generally consists of individual large cottonwood trees sometimes in galleries, groups or groves of cottonwood trees and patches consisting of cottonwood trees, and tree willow with juxtaposed shrubby willow and herbaceous understories. Generally, there is a distinct boundary between tree-dominated riparian communities and willow-dominated communities that corresponds to topography. In addition, willow is intolerant of overstory shade. Exotic trees such as elm, oak, honey locust, maple and ash are common in and adjacent to the Truckee Meadows riparian forest.

Sites supporting riparian forest include stream bank edges, abandoned or disconnected floodplains and the upper parts or backs of point and attached or mid-channel bars. The bars are the sites where tree regeneration commonly occurs but cottonwood regeneration was plentiful on other sites as well. If hydrologic conditions subsequent to establishment on bars are conducive (i.e., if scouring flows are limited), regeneration will survive and will serve to capture sediment and build floodplain surfaces through lateral or vertical bar growth. Vertical bar growth predominates in the Truckee Meadows area because of the instability of lower deposits (Water Engineering and Technology Inc., 1990).

The general goals for riparian forest should be to increase its areal extent and species and structural diversity. This can be achieved through first, preventing further losses, expanding or connecting together existing stands, and protecting regeneration. Three levels of restoration effort would be:

- Low: protect existing stands of riparian forest, including regeneration. This would include vegetation management practices aimed at long term protection, such as fencing, controlling exotics, protection from beaver damage, etc.
- Medium: protection, as above, supplemented with interplanting between disconnected trees or patches and limited expansion of patch boundaries.
- High: protection and expansion as above supplemented with creation of new patches on unforested lands. In these cases, the goal would be to create entire communities including herbaceous, shrub and tree components. Creating new patches might also require some level of geomorphic restoration.

Any of these measures assumes that existing riparian forest would be avoided by one or more flood management alternatives but not necessarily protected from future undesirable changes due to management (or lack of management) and land uses.

For purposes of assessing habitat units, changes in area of riparian forest would correspond to changes in the cottonwood habitat type (CH2M Hill, 2001). In places where both tree and shrub components are created (high restoration emphasis) both willow and cottonwood habitat types would be increased.

C. EXOTIC VEGETATION

Much of the field of restoration ecology is concerned with the eradication of exotic species from natural plant communities. Exotic plants may impair the ecological and geomorphic functions of riparian communities. They tend to be highly aggressive at colonizing disturbed sites and frequently invade riparian zones.

There is a wide variety of exotic species in and adjacent to the Truckee Meadows riparian zone. As mentioned above, exotic trees are common. Elm trees are abundant as mature trees, saplings, and seedlings. The elm is suffering from Dutch elm disease. Introduced honey locust has spread widely from a planting in a trailer park downstream from Greg Street. In some places that have been landscaped, including parks, exotics have been planted on both sides of the levee-path, effectively encroaching on residual riparian communities. Tamarisk appears to have been planted or has successfully invaded on one site. Other feral trees include Russian olive and silver maple. Exotic shrubs and herbaceous species are also common. Staghorn sumac, tree-of-heaven, Himalayan blackberry and the irrepressible white top are present. Exotic herbaceous species are too numerous to list, but include turf grasses, as well as, ruderal weeds.

It is often difficult to control exotics, especially when invasions are advanced. Exotic trees locally dominate the riparian zone in Reach 1 and part of Reach 2. The lower part of Reaches 3 and 4 is dominated by white top. The general goals should be to reduce the areal extent and dominance of exotic species and to prevent their re-invasion. Three levels of restoration effort would be:

- Low: remove existing exotic vegetation where it is currently encroaching on the riparian zone. Because of the amount of white top in Reaches 3 and 4, under low emphasis, there would be no treatment there for Alternatives 1 and 2.
- Medium: remove existing exotic vegetation where it is currently encroaching on the riparian zone and replace it with native riparian species. Manage plantings to reduce competition from exotics. Again, removal of white top in Reaches 3 and 4 would be excluded for Alternatives 1 and 2.
- High: remove existing exotic vegetation where it is currently encroaching on the riparian zone, replace with native riparian species, eliminate sources of exotic propagules (mature plants near the riparian zone), provide for continuous management of exotic vegetation. White top management would be included for all alternatives.

No general assumptions are made about the effects of alternatives on management of exotic plants. The subject is discussed only briefly in project documentation. Removal of exotics would probably have no measurable effects on habitat types except in the case where extensive patches of white top are replaced with native riparian species.

D. GEOMORPHIC FUNCTIONS

Natural geomorphic functions in stream systems include patterns of erosion and deposition that lead to construction and destruction of landforms, hydrologic variability consisting of seasonal fluctuations in surface and groundwater levels and in the case of meandering streams, lateral channel movement. Theoretically, streams are in a state of "dynamic equilibrium" in which their sediment and flow regimes are closely calibrated. However, most streams in the western USA and elsewhere are far from a natural state having been channelized, moved, artificially constrained, and affected by neighboring uses. Natural hydrologic conditions are equally rare even for streams that are not dammed but from which streamflow is diverted for various uses.

The Truckee River in the Truckee Meadows area is affected by both local and watershed-level perturbations. Approximately half of the natural streamflow is diverted for consumptive uses. This has effects on riparian ecology and sediment transport. There are upstream dams that both regulate flows as well as trap sediments. Locally, base level controls have been artificially created by diversion structures or artificially altered for flood control (Vista Reefs). The river was extensively altered in the early 1960's for flood control. Those alterations included removal of "obstructions", channelization and installment of revetment. With expanded development in the Truckee Meadows, artificial bank stabilization and local flood protection measures have increased. Since 1946 the river has widened, its planform has been simplified and it has aggraded (Reach 2) or incised (Reaches 3 and 4) (Water Engineering and Technology Inc., 1990). Bank stabilizing structures currently fix the stream in place and prevent lateral migration throughout most of the study area.

There can be no general rule for restoring geomorphic functions since every stream and watershed is unique. All that can be said is that any restoration project should be based on a thorough understanding of watershed processes (Kondolf and Micheli, 1995). A geomorphic restoration project within a stream reach can lead to undesirable geomorphic changes upstream or downstream or may be subjected to unexpected forces of destruction. Understanding the complexity of conditions affecting the Truckee Meadows area should be a prerequisite to any geomorphic restoration effort, including the proposed benching.

Given this, three levels of geomorphic restoration would include:

- Low: allow no further impairment of geomorphic functions. This would require active steps to prevent further streamflow diversions and encroachment on floodplain or channel functions.
- Medium: would include the above plus restoring connectivity of the stream to floodplains where feasible. Allowing this connectivity would restore some of the ability of the stream to meander.

- High: would include the above plus restoring connectivity of stream to floodplains on lands within project boundaries, possibly reconstructing sections of channel or floodplain to a more "natural" configuration, replacing artificial banks with natural bank materials and riparian vegetation and restoring streamflows by reducing or eliminating diversions.

The flood damage reduction alternatives are based on different levels of stream channel modifications. As a consequence, they inherently create different geomorphic restoration possibilities.

CHAPTER 5 - RESTORATION PROPOSALS

The restoration proposals presented in this section are described by stream reach, by flood damage reduction alternative and by level of restoration emphasis (high, medium and low). Maps provided with this report depict these proposals. There are four components to restoration: stream banks, riparian forest, exotic vegetation and geomorphology. Vegetation restoration efforts could include protection of existing vegetation, management to encourage natural regeneration and/or planting native vegetation or eradicating exotics. Geomorphic restoration could include bank treatments, reconnecting the stream to its floodplain to benefit restoration and/or major channel reconstruction. Choosing one level of emphasis for one component does not necessarily require choosing the same level for other components, but it may as in the case of channel reconstruction and riparian forest restoration. Consequently, there is a myriad of possibilities. The fundamental choice, however, is which flood damage reduction alternative is selected. In large part, that choice will determine the spatial constraints or opportunities for restoration.

A. REACH 1

Under any alternative, flood damage reduction efforts in Reach 1 are essentially identical. They consist of augmentations to existing levees and floodwalls to provide a higher level of protection. Consequently, restoration opportunities are almost entirely the same for all three alternatives (Plates 2, 3, and 4).

1. Stream Banks

For stream banks, under a low restoration emphasis, approximately 5,305 linear feet of bank would continue to revegetate naturally, eventually achieving a fully vegetated condition if provided proper management (Table 1). The time frame would be longer for presently barren banks than it would be for partially vegetated banks. Any future bank stabilization projects would be done with biotechnical approaches. With a medium level of restoration emphasis some riprap would be selectively removed and riparian species would be planted to help accelerate revegetation. This would concentrate on banks that are currently barren. Under a high restoration emphasis, riprap and other artificial bank stabilizing materials would be removed where currently barren. Those locations would be treated with biotechnical bank stabilization. Any future bank stabilization would be done with bioengineering methods.

TABLE 1

STREAM BANK TREATMENTS – REACH 1

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Manage for natural regeneration on partially vegetated and barren banks (5,305 linear feet). Require biotechnical bank stabilization for new projects (amount undetermined).	Partially remove riprap in selected locations that are currently barren (481 linear feet). Plant willow and cottonwood to accelerate revegetation.	Totally remove riprap and other materials from 481 linear feet of currently barren bank. Replace with bioengineered stabilization structures.
Alternative 2			
Coalition Alternative			

2. Riparian Forest

Under a low restoration emphasis, existing riparian forest, consisting primarily of cottonwood trees, would be protected from removal or damage during construction (Table 2). Existing regeneration would also be protected, as necessary, to ensure its survival. Over time, the amount of riparian forest would incrementally increase within levee and floodwall boundaries. Under a medium emphasis, interplanting with native riparian trees, largely cottonwood, would be done both along the north and south banks to increase riparian connectivity. Efforts would be made to expand and connect existing stands or scattered trees. This would eventually create an additional 7.4 acres of native riparian forest. Implementing a high restoration emphasis on riparian forest in Reach 1 would involve creating a new riparian patch in Fisherman's Park between Highway 395 and Glendale Avenue. This would cover 6.6 acres and require some grading to create a suitable surface where slopes are steep.

TABLE 2

RIPARIAN FOREST TREATMENTS – REACH 1

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Retain all existing native riparian trees. Protect existing and future regeneration.	Interplant in available space on both sides of the river within the vicinity of existing trees or patches (7.4 acres).	Create 6.6 acres of riparian forest on north bank between Highway 395 and Glendale Avenue.
Alternative 2			
Coalition Alternative			

3. Exotic Species

The main exotic species found in Reach 1 is elm, although there are other exotics planted in and adjacent to the riparian zone. Under a low restoration emphasis, exotics would be removed only if they are directly encroaching on the riparian zone (Table 3). This would require follow-up treatments with manual or chemical methods to control resprouting. It would be assumed that natural regeneration of native species would re-occupy the cleared sites. Under a medium emphasis, exotics would be removed and native species would be immediately planted to replace them. Follow-up treatments would be applied to prevent the exotics from out-competing the natives. With a high restoration emphasis, exotics would be removed, and native species would be replanted plus sources of invasive exotics would be removed. This would require removal of some landscaping on both sides of the river. Management prescriptions preventing use of invasive exotics for landscaping and ensuring against future invasions would be implemented in perpetuity.

It is not possible to pinpoint the area that would be treated for exotic vegetation control in Reach 1. Rather, the effort would apply to the entire reach and would not be concentrated in any one location. There are no large contiguous patches of exotics in this reach.

TABLE 3

EXOTIC SPECIES TREATMENTS – REACH 1

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Identify and remove all exotic trees and shrubs from the riparian zone. Prevent re-establishment with follow-up treatments.	Remove exotics and replant with native riparian species (willow and cottonwood). Control competition from exotics.	Remove sources of invasive exotics. Prevent the use of invasive exotics for landscaping.
Alternative 2			
Coalition Alternative			

4. Geomorphic Restoration

Opportunities for geomorphic restoration in Reach 1 are limited under any alternative (Table 4). Under a low emphasis, the principle objective would be to prevent further impairment. That would mainly mean no further use of artificial bank stabilization. It is unlikely that further streamflow diversions would be permitted in this reach in any event. Under a medium emphasis, no additional measures are proposed. Under a high restoration emphasis barren artificial bank stabilization would be removed where currently barren and replaced with bioengineered structures. Future bank protection, if any, would be done with bioengineering methods. Grading would be done along steep slopes in Fisherman's Park to create a suitable surface for riparian restoration. Additional measures such as channel reconstruction or removal of diversion structures are not deemed feasible. In fact, removing diversion structures that currently provide local base control for this reach would have a de-stabilizing effect with unpredictable results.

TABLE 4

GEOMORPHIC RESTORATION TREATMENTS – REACH 1

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Prevent future use of artificial bank stabilization, require bioengineered structures instead.		Remove all barren artificial bank stabilization and replace with bioengineered structures. Require any future bank stabilization to be done with bioengineering methods. Create a surface for riparian restoration along the north bank in Fisherman's Park.
Alternative 2			
Coalition Alternative			

B. REACH 2

In both Reaches 2 and 3 the main difference between the alternatives is that the Community Coalition Alternative would totally reconstruct the channel on the south side of the river.

Otherwise, the treatment on the north side of the river would be similar and the restoration opportunities would also be similar with some minor exceptions. The Community Coalition Alternative also procures a substantial amount of land on the south side of the river for park or parkway use. It is anticipated that park use could be coordinated with restoration efforts at least to some degree. Some of this land would be within the boundaries of levee systems under Alternatives 1 and 2 and would also represent lands available for restoration.

Restoration proposals for Alternatives 1 and 2 are illustrated on Plates 5a, 5b, 6a, 6b, 7a, and 7b. The Community Coalition Alternative proposals are depicted on Plates 8a, 8b, 9a, 9b, 10a, and 10b.

1. Stream Banks

In Reach 2, under the Community Coalition Alternative, 9,237 linear feet of stream bank would be removed on the south side of the river and replaced with benches. These would require some treatment at the intersection of higher and lower terraces and at the intersection of the higher terrace and adjacent lands, essentially doubling the length of bank on the south side of the river. The total length of new bank that would be created under that alternative is estimated at 18,474 linear feet. Under a low restoration emphasis new banks would be treated for erosion control with by hydroseeding with native species or other methods. Judging from the abundance of natural regeneration on bars and elsewhere in the study area, cottonwoods and willows would colonize the bench surfaces. However, the rate of natural regeneration would depend on specific substrate conditions and streamflow regime. The north side of the river would be managed for natural regeneration of currently barren or partially vegetated banks (2,802 linear feet).

Under a low restoration emphasis for Alternatives 1 and 2, all existing barren or partially vegetated banks on both sides of the river would be managed for natural regeneration (5,372 linear feet). Future stabilization projects would be done with bioengineering structures.

With a medium restoration emphasis, the treatment would be the same for all alternatives on the north side of the river. Existing barren riprap would be removed in selected barren locations and riparian species would be planted to accelerate revegetation. On the south side of the river, the same practice could be implemented for Alternatives 1 and 2, but would not apply to the Community Coalition Alternative.

If a high restoration emphasis were applied to Alternatives 1 and 2, then 100 linear feet of existing barren riprap would be removed and replaced with bioengineered structures. Any future bank stabilization projects would be done with bioengineered structures. It is not possible to anticipate where those may occur in the future. In application to the Community Coalition Alternative, riprap would be removed only from the north bank, a total of 100 linear feet, and replaced with bioengineered structures. Bioengineering would be applied to the entire new channel, a distance of 9,237 linear feet.

TABLE 5

STREAM BANK TREATMENTS – REACH 2

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1 Alternative 2	Manage for natural regeneration on partially vegetated and barren banks (5,372 linear feet). Require biotechnical bank stabilization for new projects (amount undetermined).	Partially remove riprap in selected barren locations on both sides of the river (100 linear feet). Plant willow and cottonwood to accelerate revegetation.	Totally remove riprap and other materials from 100 linear feet of currently barren bank. Replace with bioengineered stabilization structures. Use bioengineered structures for any future projects.
Coalition Alternative	Manage for natural regeneration on partially vegetated and barren banks on north side of river (2,802 linear feet). Apply erosion control measures to newly created banks on south side of river (9,237 linear feet). Require biotechnical bank stabilization for new projects on north side of river (amount undetermined).	Partially remove riprap in selected locations on the north side of the river (100 linear feet). Plant willow and cottonwood to accelerate revegetation. No additional measures for the south side of the river.	Totally remove riprap and other materials from 100 liner feet of bank on the north side of the river. Replace with bioengineered stabilization structures. Use bioengineered structures to stabilize banks on south side of river (9,237 linear feet).

2. Riparian Forest

Under a low restoration emphasis, efforts would be made to protect and preserve existing riparian forest, including regeneration. This could be easily accomplished with Alternatives 1 and 2 but would require significant design changes in the Community Coalition Alternative on the south side of the river. At this time, no design changes to the Community Coalition Alternative are proposed for a low or medium restoration emphasis. Benching associated with the Community Coalition Alternative would allow for 62.2 acres of riparian habitat (70 percent willow and 30 percent cottonwood).

A medium restoration emphasis would include protection of existing riparian forest plus interplanting and expansion of existing forest within project boundaries. If interplanting and expansion were to concentrate on locations where forest currently exists, there would be a total of 14.1 acres potentially created under Alternatives 1 and 2. Under the Community Coalition Alternative, 3.1 acres on the north bank would be available for riparian expansion. Proposed riparian forest plantings on the south bank will cover 11.2 acres north of Pioneer Ditch between Rock Boulevard and Greg Street.

A high restoration emphasis for riparian forest would entail creation of new forest patches where none currently exist but where vacant lands are available. In Reach 2, there are limited lands

available for this purpose on the north side of the river under any alternative. The alternatives all provide ample land on the south side of the river within project boundaries. Alternatives 1 and 2 would each have the potential to create 109.8 acres of new riparian forest. The Community Coalition Alternative would create an even larger area of 125.1 acres. Under a high restoration emphasis design changes would be implemented in the Community Coalition Alternative to create two islands in Reach 2. The feasibility of these changes requires further study.

If the lands within the benched area under the Community Coalition Alternative are considered lands for restoration, they represent an additional area of 40 acres that could be restored to native riparian forest using low or medium emphasis. It is assumed that the lower bench could be regenerated to a willow community (30 percent) and the higher bench to a cottonwood forest (70 percent).

TABLE 6

RIPARIAN FOREST TREATMENTS – REACH 2

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Retain all existing native riparian trees. Protect existing and future regeneration.	Interplant and expand forest boundaries in available space on both sides of the river (14.1 acres).	Create new riparian forest patches on 109.8 acres.
Alternative 2			
Coalition Alternative	Same as Alternatives 1 and 2 on north side of river. On south side of river, existing riparian forest would be within the boundaries of benched area.	Same as Alternatives 1 and 2 on north side of river (3.1acres). Create new riparian forest patches between Greg Street and Rock Boulevard. Create 11.2 acres of new habitat on the south bank north of Pioneer Ditch	Create new riparian forest patches on 125.1acres. This would mean an additional 40 acres.

3. Exotic Species

There are several exotic species throughout Reach 2, including a concentration of tree-of-heaven just upstream from McCarran Boulevard. Under a low restoration emphasis, exotics within the riparian zone would be removed. Follow-up treatments would also be applied to prevent re-invasion. Since most exotics are on the north side of the river, the level of effort would be similar for any alternative.

A medium emphasis on exotic control would require planting of sites cleared of exotics with native species and follow-up management. Again, the level of effort would be similar for all alternatives.

If a high restoration emphasis were chosen, then removal of exotics and replanting would be followed by removal of sources of exotics. On the north side of the river, the main sources of

exotics are the trailer park landscaping downstream from Greg Street, Rock Park and other landscaping associated with industrial development. Exotic species treatments under any emphasis would apply to the reach as a whole.

TABLE 7

EXOTIC SPECIES TREATMENTS – REACH 2

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Identify and remove all exotic trees and shrubs from the north side of river. Prevent re-sprouting.	Remove exotics and replant with native riparian species (willow and cottonwood). Control competition from exotics.	Remove sources of exotic species.
Alternative 2			
Coalition Alternative			

4. Geomorphic Restoration

All three alternatives provide opportunities for both minor and major geomorphic restoration within Reach 2. Minor geomorphic restoration would be selective removal of artificial bank stabilization on currently barren bank, as previously discussed, or selective reconnection of the stream to its floodplain through levee breaching or other measures. Major geomorphic restoration could involve channel relocation and reconstruction. The Community Coalition Alternative for benching on the south side of the channel is a major geomorphic restoration project. It is intended to create two floodplain levels next to the existing channel. Its feasibility and potential effects both upstream and downstream from the study area should be thoroughly evaluated.

Under a low restoration emphasis, Alternatives 1 and 2 would permit no further impairment of geomorphic functions. That would be facilitated in part, by the levee and floodwall setbacks. Within the setback areas, no steps would be taken to prevent the natural behavior of the stream. For the Community Coalition Alternative, the proposed levees and floodwalls on the north side of the stream would have identical effects. However, given the changes that would occur due to benching on the south side of the stream, a low restoration emphasis would not be relevant for that alternative.

Under a medium restoration emphasis, existing riparian forest on the north bank within the floodplain could be reconnected to the stream. This opportunity would be the same for all alternatives. Additional lands might benefit on the south side of the river under Alternatives 1 and 2 but specific measures are not being proposed at this time.

Under a high restoration emphasis, lands contained within project boundaries present opportunities for channel reconstruction in conjunction with riparian forest restoration. Artificial bank stabilization structures could be removed where barren and replaced with bioengineered structures. Efforts could be made to eliminate any diversions from the reach. For Alternatives 1 and 2, major geomorphic reconstruction would include creation of a highflow channel (1.7 acres)

on the south side of the river in conjunction with riparian forest planting. This would be in addition to 4.3 acres of minor geomorphic restoration on the north side of the river. For the Community Coalition Alternative, on the south side of the river, major geomorphic restoration would include creation of two highflow channels totaling 13.2 acres. This would create two islands due to re-aligning the proposed new channel. Including the benching on the south side of the river as a geomorphic restoration area under the Community Coalition Alternative would mean an additional 40 acres.

TABLE 8

GEOMORPHIC RESTORATION TREATMENTS – REACH 2

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Allow natural stream behavior within the boundaries of levees and floodwalls. Prevent further encroachment and streamflow diversions.	Reconnect stream to floodplains with riparian forest on 4.3 acres, on north bank of the river.	Major geomorphic reconstruction on 1.7 acres in conjunction with riparian forest restoration. Eliminate diversions.
Alternative 2			
Coalition Alternative	Identical to other alternatives on north side of river. Not relevant on south side of river.	Allow natural stream behavior within levees and floodwalls plus reconnect stream to floodplains with riparian forest on 4.3 acres on the north bank of the river.	Re-align proposed channel (13.2 acres) to create two islands in conjunction with riparian forest restoration. Eliminate diversions. Grading would create 40 acres of benched floodplain.

C. REACHES 3 AND 4

Restoration of Reaches 3 and 4 will be a special challenge because of the unstable geomorphology and degree to which the riparian zone has been degraded. Although proposals are presented below for the three alternatives, implementation of any restoration actions should be preceded by thorough analysis to discern the underlying problems. Such analysis should be done with a watershed-wide perspective as recommended by USACE policy.

Reaches 3 and 4 would be treated similarly to Reach 2 under the three alternatives with one notable exception. Alternative 2 proposes a large detention facility on the south side of the river. It is assumed that that detention basin will provide no special opportunities for restoration. It will function only during flood events and otherwise would remain in its existing agricultural use. For purposes of evaluating restoration, it is assumed that in all three alternatives land currently owned by the University of Nevada on the south side of the river might be available for restoration. It is also assumed that any restoration of those lands would have to be closely coordinated with restoration of Steamboat Creek. Currently, there is a proposal to reconstruct the channel and floodplain of Steamboat Creek (USACE, 2001 and S. Swanson, pers. comm.).

Restoration proposals for Alternative 1 are illustrated on Plates 11a, 11b, 11c, 12a, 12b, 12c, 13a, 13b, and 13c. Alternative 2 restoration proposals are illustrated on Plates 14a, 14b, 14c, 15a,

15b, 15c, 16a, 16b, and 16c. The Community Coalition Alternative proposals are depicted on Plates 17a, 17b, 17c, 18a, 18b, 18c, 19a, 19b, and 19c.

1. Stream Banks

Under any alternative, the extent of barren bank in Reaches 3 and 4 indicates the need for a major restoration effort (2,645 linear feet is currently barren). Under the Community Coalition Alternative, all of the bank on the south side of the channel would be replaced with benches. The total length of new bank would be 37,514 linear feet or twice the existing length. If the geomorphic conditions in the reach were improved by the benching, it is possible that conditions for natural or artificial regeneration would also be improved. Currently, barren banks are too steep in many places to permit plant establishment. Also, the presence of white top currently prevents native plant regeneration. Bank conditions could be improved, exotic vegetation could be cleared and surfaces could be created in ways that facilitate restoration with native species. With those provisions, a low restoration emphasis, utilizing erosion control treatments for banks, and depending on natural regeneration to revegetate surfaces, might be successful in the Community Coalition Alternative. Depending on managing natural regeneration to improve conditions on the north bank, which would not be altered by the Community Coalition Alternative, would require aggressive control of exotics.

For Alternatives 1 and 2 that propose no channel changes, a low emphasis on bank restoration would apply to 15,199 linear feet of currently barren or partially vegetated bank on both sides of the river. Based on conditions in the reach, it may be feasible to manage for natural regeneration in the upstream third of the reach. In the lower portion above and below Steamboat Creek managing for natural regeneration of currently barren or partly vegetated banks would have to be accompanied by aggressive control of exotics. Much of the downstream part of the reach would not be treated because it is currently fully vegetated with white top.

A medium restoration emphasis on banks, in which barren riprap would be removed in selected locations, is not very relevant in Reaches 3 and 4. Under Alternatives 1 and 2, on the south bank of the river, 91 linear feet of bank would be treated.

A high restoration emphasis on stream bank restoration in Reaches 3 and 4 might be the only realistic approach to any alternative that is ultimately adopted. Underlying causes of existing bank instability would need to be addressed first. However, a high restoration emphasis would have a different approach in Reaches 3 and 4. On the south bank, bioengineered structures would be applied to any banks that are currently barren or would be barren in the future (i.e., newly created channel). This would apply to 2,645 linear feet for Alternatives 1 and 2 and 18,757 linear feet for the Community Coalition Alternative. Bioengineering technology would also be applied to any new bank protection projects.

TABLE 9

STREAM BANK TREATMENTS – REACHES 3 AND 4

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1 Alternative 2	Manage for natural regeneration on partially vegetated and barren banks (15,199 linear feet). Require biotechnical bank stabilization for new projects (amount undetermined).	Not relevant since most barren banks are currently unprotected.	Use bioengineered structures to stabilize and vegetate 2,645 linear feet of currently barren bank, removing riprap where present. Use bioengineered structures for any future projects.
Coalition Alternative	Manage for natural regeneration on partially vegetated and barren banks on north side of river (6,418 linear feet). Apply erosion control measures to newly created banks on south side of river (18,757 linear feet). Require biotechnical bank stabilization for new projects on north side of river (amount undetermined).	Not relevant since most barren banks are currently unprotected.	Use bioengineering structures to stabilize new banks on the south side of the river 18,757 linear feet).

2. Riparian Forest

Virtually all remnant riparian forest is located in the upstream third of this reach. For Alternatives 1 and 2, all riparian forest would be retained and protected under a low restoration emphasis. For the Community Coalition Alternative, riparian forest on the north side of the river would be protected. Riparian forest is expected to establish on the south bank of the river under natural processes on benches, covering 146.2 acres.

Under a medium restoration emphasis for Alternatives 1 and 2, protection of existing riparian forest would be augmented by geomorphic restoration and interplanting and expansion of the existing forest. This would apply to the upstream third of the reach. These measures could increase riparian forest in the upstream part of the reach by 11.9 acres. Interplanting would not be relevant under any alternative downstream where forest is almost entirely absent. On the south side of the river, unless some or all existing riparian forest could be avoided by design changes in the Community Coalition Alternative, interplanting and expansion is not proposed. Riparian forest would establish on the proposed benches following planting with willows and cottonwoods, covering 146.2 acres.

A high restoration emphasis on riparian forest would involve a rather large effort in Reaches 3 and 4 where riparian forest is scarce. Levee setbacks on the north bank would allow planting of trees throughout the reach (outside of areas already proposed for expansion) in a zone

approximately 20-50 feet wide and covering 8.2 acres. This is only shown in the upper third of the reach on Plates 18a, 18b, 18c, 19a, 19b, and 19c because other measures, mainly control of exotics, would be required to make it feasible downstream. If a high emphasis on controlling exotics were adopted, then this new forest could be extended further. However, the scope of such a restoration effort should not be underestimated.

There are limited opportunities to create new riparian forest on the north bank of the river, however 8.2 acres of habitat could be developed at the mid point of the reach. There is extensive undeveloped land on the south side of the river that could be used to create new riparian patches. This land is currently owned by the University of Nevada and may be available in part for restoration if it is acquired by the USACE. In conjunction with a major geomorphic restoration project, a gallery forest could be created on the south side of the river under Alternatives 1 and 2 in a zone 350 feet wide, creating an additional 164.3 acres of new forest.

TABLE 10

RIPARIAN FOREST TREATMENTS – REACHES 3 AND 4

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Retain all existing native riparian trees. Protect existing and future regeneration.	Interplant and expand forest boundaries in available space on both sides of the river (11.9 acres).	Create new riparian forest patches on 164.3 acres.
Alternative 2			
Coalition Alternative	Same as Alternatives 1 and 2 on north side of river. On the south bank of the river, new riparian forest would be established by natural processes on the proposed benches (146.2 acres).	On north side of river interplant and expand any remaining forest (7.1 acres). Plant benches on south side of the river with native species (146.2 acres).	Create new riparian forest patches on 8.2 acres on north side of the river.

3. Exotic Species

The degree to which exotic species, mainly white top, have invaded Reaches 3 and 4 implies both significant risk of further degradation as well as a constraint to restoration efforts. Generally, incremental attempts to control white top would yield few benefits. Other exotic trees and shrubs are present in Reaches 3 and 4 and might be feasibly controlled by limited efforts. These are mostly associated with landscape plantings. A low or medium restoration emphasis on controlling exotic vegetation might be feasible in the upper third of the reach, at least temporarily. In the long term, the underlying causes for the presence of white top, which may include changes in hydrology and geomorphology in this reach would be needed to prevent its spread and reinvasion of cleared areas.

For these reasons, low and medium emphasis on controlling exotics is only proposed for Reaches 3 and 4 above the first occurrences of white top (upper third of the reach). Under Alternatives 1

and 2, this would apply to both sides of the river. Under the Community Coalition Alternative, it would only apply to the north side of the river.

A high emphasis on exotic vegetation control would include the above measures plus it would involve a major effort to control white top. This effort would have to include a thorough analysis of the underlying ecological and physical causes for the presence of white top. At the present time, the species is dominant throughout the riparian zone below Steamboat Creek, is achieving dominance over native species above Steamboat Creek and fully occupies much of the adjacent terrace at the Steamboat-Truckee confluence. Simply clearing the white top from the Truckee River riparian zone would be a monumental effort in itself, applying to 14.9 acres. Preventing its re-invasion would be unlikely unless the underlying causes for its presence were addressed.

The white top problem not only pertains to existing riparian conditions. Under the Community Coalition Alternative, benching would be used to create a new channel. Even if a high emphasis on bank treatment were implemented, i.e., if newly created banks and surfaces were aggressively treated with bioengineered structures and planting, this will be a prime area for further white top invasion. The inter-relatedness among the dysfunctional geomorphology and hydrology and degraded riparian conditions in this reach must be evaluated to reduce uncertainty about future conditions.

On the positive side, the Community Coalition Alternative proposes benching on the south side of the river throughout the reach. This would entail removal of all existing banks and associated vegetation, including all white top. This would amount to clearing 9 acres currently occupied by white top. Although a step in the direction of control, this would not solve the problem of future invasion by white top into the created channel or elsewhere in the riparian zone.

TABLE 11

EXOTIC SPECIES TREATMENTS – REACHES 3 AND 4

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Identify and remove all exotic trees and shrubs from both sides of river in upper third of reach. Prevent re-sprouting.	Remove exotics and replant with native riparian species (willow and cottonwood) on both sides of the river in upper third of reach. Control competition from exotics.	Implement measures in upper third of reach. Evaluate underlying causes for riparian degradation and develop control program for white top for entire reach (14.9 acres).
Alternative 2			
Coalition Alternative	Identify and remove all exotic trees and shrubs from the north side of river in upper third of reach. Prevent re-sprouting. All vegetation, including exotics, would be cleared from the south side of the river.	Remove exotics and replant with native riparian species (willow and cottonwood) on north side of river in upper third of reach. Control competition from exotics. All vegetation, including exotics, would be cleared from the south side of the river.	Implement measures on north side of river in upper third of reach. Evaluate underlying causes for riparian degradation and develop control program for white top remaining on the north bank (5.8 acres).

4. Geomorphic Restoration

The geomorphic instability in Reaches 3 and 4 warrants detailed assessment before any flood damage reduction alternative is adopted and implemented. Available information indicates that the stream is continuing to incise, thereby creating bank instability. The problems seem to be more complex than just changes in base level at Vista Reef. A watershed-wide perspective is needed to understand how a flood damage reduction alternative will affect and be affected by, this geomorphic instability. The issue is not confined to Reaches 3 and 4 but also applies to Reach 2 and to other sections of the river outside the immediate study area.

A low emphasis on geomorphic restoration in Reaches 3 and 4 does not seem appropriate under any alternative. There is too much uncertainty at present about how a flood damage reduction alternative will behave in the future.

For all alternatives, a medium emphasis on geomorphic restoration could be implemented in two areas on the north side of the river in the upstream part of this reach under any alternative. At these sites, levee breaching or other measures could be used to re-connect the stream to remnant riparian forest, creating an additional 8.8 acres of riparian forest.

There is a large area (105.5 acres) on the south side of the river that could be potentially available for major geomorphic restoration for a high resolution emphasis under any alternative. As stated above, undertaking such a project would require much more detailed study. One concept would be to create one or more channels through the area lying between the river and Steamboat Creek in conjunction with riparian forest restoration. This must be coordinated with planned restoration of Steamboat Creek. There are no areas available for major geomorphic restoration on the north side of the river.

TABLE 12

GEOMORPHIC RESTORATION TREATMENTS – REACHES 3 AND 4

Alternative	Low Emphasis	Medium Emphasis	High Emphasis
Alternative 1	Not appropriate due to uncertainty about future stream behavior.	Use levee breaching or other measures to re-connect stream to riparian forest patches in two areas (8.8 acres) on north bank.	Undertake detailed evaluation of geomorphic and hydrologic processes. Design channel construction on the south side of the river in conjunction with riparian restoration (105.5 acres). Coordinate with restoration of Steamboat Creek.
Alternative 2			
Coalition Alternative		Use levee breaching or other measures to re-connect stream to riparian forest patches in two areas (8.8 acres) on north bank.	

CHAPTER 6 - SUMMARY AND FURTHER STUDIES REQUIRED

Tables 13 and 14 summarize the restoration proposals for the Truckee Meadows under the three flood damage reduction alternatives. Alternatives 1 and 2 have a similar restoration potential in Reaches 1, 2, and 4. In Reach 3, the restoration potential of Alternative 2 will be reduced to allow for the placement of detention basin inlets and/or outlets to the river. This reduction in area available for restoration will be determined with conceptual design of these structures. The UNR detention basin associated with Alternative 2 has been judged to have no additional restoration potential. All alternatives have similar restoration potential for the north side of the river. Under each successive level of restoration emphasis all provisions of the next lower level would be included (i.e., high emphasis includes all low and medium emphasis proposals)

TABLE 13

SUMMARY OF RESTORATION PROPOSALS UNDER LOW, MEDIUM, AND HIGH RESTORATION EMPHASIS – ALTERNATIVES 1 AND 2

Low Emphasis	Medium Emphasis	High Emphasis
Banks: Manage for natural regeneration on partially vegetated and barren banks (25,876 linear feet). Require biotechnical bank stabilization for new projects (amount undetermined).	**Banks:** Partially remove riprap in selected barren locations on both sides of the river (581 linear feet). Plant willow and cottonwood to accelerate revegetation.	**Banks:** Totally remove riprap and other materials from 3226 linear feet of currently barren bank. Replace with bioengineered stabilization structures.
Riparian Forest: Retain all existing native riparian trees. Protect existing and future regeneration.	**Riparian Forest:** Interplant and expand forest boundaries in available space on both sides of the river (33.4 acres).	**Riparian Forest:** Create new riparian forest patches on 280.7 acres.
Exotic Species: : Identify and remove all exotic trees and shrubs. Prevent re-sprouting.	**Exotic Species:** Remove exotics and replant with native riparian species (willow and cottonwood). Control competition from exotics.	**Exotic Species:** Remove sources of invasive exotics. Prevent the use of invasive exotics for landscaping. Evaluate underlying causes for riparian degradation and develop control program for white top (14.9 acres).
Geomorphic Restoration: Prevent future use of artificial bank stabilization, require bioengineered structures instead. Allow natural stream behavior within the boundaries of levees and floodwalls. Prevent further encroachment and streamflow diversions.	**Geomorphic Restoration:** Prevent future use of artificial bank stabilization, require bioengineered structures instead. Reconnect stream to floodplains with riparian forest on 13.2 acres, on north bank of the river.	**Geomorphic Restoration:** Remove all barren artificial bank stabilization and replace with bioengineered structures. Require any future bank stabilization to be done with bioengineering methods. Create a surface for riparian restoration along the north bank in Fisherman's Park. Undertake detailed evaluation of geomorphic and hydrologic processes. Design channel construction on the river in conjunction with riparian restoration (107.2 acres). Coordinate with restoration of Steamboat Creek.

TABLE 14

SUMMARY OF RESTORATION PROPOSALS UNDER LOW, MEDIUM, AND HIGH RESTORATION EMPHASIS – COMMUNITY COALITION ALTERNATIVE

Banks: Manage for natural regeneration on partially vegetated and barren banks (14,525 linear feet). Apply erosion control measures to newly created banks on south side of river (27,994 linear feet). Require biotechnical bank stabilization for new projects	**Banks:** Partially remove riprap in selected barren locations on both sides of the river (581 linear feet). Plant willow and cottonwood to accelerate revegetation.	**Banks:** Totally remove riprap and other materials from 581 linear feet of currently barren bank. Replace with bioengineered stabilization structures. Use bioengineered structures to stabilize banks on south side of river (27,994 linear feet).
Riparian Forest: Retain all existing native riparian trees. Protect existing and future regeneration. Manage for natural regeneration on 146.2 acres of newly created benches.	**Riparian Forest:** Expand existing riparian forest to 17.6 acres. Create new forest patches on 14.4 acres. Plant benches on south side of the river.	**Riparian Forest:** Create new forest patches on 139.9 acres.
Exotic Species: Identify and remove all exotic trees and shrubs. Prevent re-sprouting.	**Exotic Species:** Remove exotics and replant with native riparian species (willow and cottonwood). Control competition from exotics.	**Exotic Species:** Remove sources of invasive exotics. Prevent the use of invasive exotics for landscaping. Evaluate underlying causes for riparian degradation and develop control program for white top (5.8 acres).
Geomorphic Restoration: Prevent future use of artificial bank stabilization, require bioengineered structures instead. Allow natural stream behavior within the boundaries of levees and floodwalls. Prevent further encroachment and streamflow diversions.	**Geomorphic Restoration:** Prevent future use of artificial bank stabilization, require bioengineered structures instead. Allow natural stream behavior within levees and floodwalls plus reconnect stream to floodplains with riparian forest on 13.2 acres on the north bank of the river.	**Geomorphic Restoration:** Remove all barren artificial bank stabilization and replace with bioengineered structures. Require any future bank stabilization to be done with bioengineering methods. Create a surface for riparian restoration along the north bank in Fisherman's Park. Undertake detailed evaluation of geomorphic and hydrologic processes. Design channel construction on the south side of the river in conjunction with riparian restoration (105.5 acres). Coordinate with restoration of Steamboat Creek. Re-align proposed channel (13.2 acres) to create two islands in conjunction with riparian forest restoration. Eliminate diversions. Grading would create 40 acres of benched floodplain.

There are a wide variety of potential restoration activities that could be conducted in the study area. Considering their likelihood of success should be of paramount importance. Some activities could be done with little technical uncertainty in some locations under some alternatives. For example, Reach 1 is relatively stable geomorphically, all alternatives propose the same flood damage reduction, and the opportunities for restoration are clearly defined. At the other extreme, Reaches 2 and 3 are unstable geomorphically, restoration could be conducted at many different sites and at different levels and the flood damage reduction alternatives differ radically. In this study, the approach taken has been analyzing restoration on a stream reach, rather than at a site level. However, at the stream reach level there are many unknowns that require further study.

- First and foremost, the existing geomorphic processes in the study area (and in the surrounding watershed) need to be understood. Only then can detailed restoration planning and design be completed with some assurances of success. This understanding is necessary for conducting evaluations of the hydrologic and geomorphic effects of the alternatives as well (see below).

Adopting a low emphasis on restoration for some or all components (banks, riparian forest, exotic species and geomorphology) would not be the option with the lowest technical uncertainty. As discussed above, depending on "natural" processes to accomplish restoration is not advisable in a study area that is in such a dysfunctional state. However, a low emphasis approach could work in some locations for some purposes, such as bank restoration in Reach 1.

- If managed natural recovery is adopted as a strategy for any alternative or reach, further study is required. Specifically, surfaces and banks created by benching under the Community Coalition Alternative must be favorable for regeneration by any means natural or artificial, while remaining stable during peak flows. At present, the conditions required for that (bank slope and surface substrate) are unknown.

- Natural regeneration depends upon availability of propagules and appropriate streamflow conditions. This relationship needs to be established so that streamflow management practices can be specified. In the past, streamflow management was effective in promoting cottonwood regeneration on the Truckee River below Wadsworth (and undoubtedly in the study area as well) (S. Swanson, pers. comm.). However, this opportunity was created by antecedent precipitation, something that is uncontrollable.

- Depending on natural regeneration in areas dominated by exotics is not recommended unless aggressive vegetation management practices will be applied. In particular, the proposed benching will create a great opportunity for further invasion by exotic plants.

Conversely, adopting a high emphasis on restoration would be equally problematic without a better understanding of underlying geomorphology and causes of degradation. The Community Coalition Alternative is proposing major geomorphic restoration. In that context, it should be viewed as the project with the greatest technical uncertainty that requires further detailed evaluation. Moreover, committing to that alternative may also commit the project to undertaking high emphasis on restoration in the other components, including bank treatments, riparian forest restoration and exotic vegetation control.

- Once watershed geomorphic processes are understood, the Community Coalition Alternative (and other alternatives) should be subjected to further study to determine their stability, behavior and effects.

Some of the restoration components are intricately related and could not be pursued independently. For example, creating new riparian patches may also necessitate geomorphic restoration in some cases. In some places, for some alternatives, some options are not available. When making choices on the degree of emphasis for the different components, these interrelationships must be remembered. Further, if riparian planting or minor or major geomorphic restoration projects were pursued, additional design would be needed.

- For riparian plantings, the choice of plant materials should be based on the species naturally occurring in the study area. Local seed sources or vegetative elements are preferred. Bioengineered bank treatments and willow plantings generally should be done with cuttings from the study area. Tree plantings should be done with cottonwood using local seed. All planting projects should have a vegetation management component addressing irrigation and competition control during and following the establishment period.
- For geomorphic restoration, further studies must be done to determine the best designs for levee breaching or channel reconstruction. Those studies must consider potential effects on streamflow and flood management.

Ultimately, the choice of restoration options will hinge on the choice of flood damage reduction alternative. The alternatives with the least technical uncertainty, from a restoration standpoint, are the two levee-floodwall alternatives. Both preserve existing riparian vegetation, both allow some restoration of stream geomorphic functions due to levee set-backs and both provide ample space for creation of new habitats. Their main limitation is that they do not address the current problems with the stream (e.g., aggradation in Reach 2, incision in Reaches 3 and 4). Although the Community Coalition Alternative poses the technical uncertainty, potentially removing most riparian vegetation and creating a new channel, it could be designed in a way to improve stream functions. At the present time, there is not enough information to make that finding.

CHAPTER 7 - REFERENCES

Literature Cited

CH2M Hill, 2001. Habitat Evaluation Procedure Analysis of the Truckee River Flood Control Project and Habitat Restoration Plan. United States Army Corps of Engineers, Sacramento District, Sacramento, CA.

CH2M Hill, 2000. Conceptual Habitat Restoration Plan for Truckee Meadows. United States Army Corps of Engineers, Sacramento District, Sacramento, CA.

CH2M Hill, 1999. Truckee River Fishery Restoration Plan: Fish Screens, Fish Ladders and Riparian Shading. United States Army Corps of Engineers, Sacramento District, Sacramento, CA.

Kondolf, G.M and E.R. Micheli,1995. Evaluating Stream Restoration Projects. Environmental Management 19:1-15.

Maser, E., 2002. Letter to Mary Paasch, dated August 15, 2002, regarding Truckee River project environmental restoration.

United States Army Corps of Engineers, 2001. Section 206 Preliminary Restoration Plan, Steamboat Creek, Final Report. United States Army Corps of Engineers, Sacramento District, Sacramento, CA.

United States Army Corps of Engineers, 2000. Reno-Sparks-Truckee Meadows Flood Damage Reduction and Environmental Restoration Alternatives Report. United States Army Corps of Engineers, Sacramento District, Sacramento, CA.

Water Engineering and Technology, Inc., 1990. Final Report, Geomorphic Analysis of Truckee River from RM 56 (Ambrose Park in Reno) to RM 43 (Vista), Steamboat Creek, Boynton Slough. United States Army Corps of Engineers, Sacramento District, Sacramento, CA.

Personal Communications

Amando Padilla, USACE, Sacramento District, telephone conversation, August 29, 2002.

Sherm Swanson, UNR, telephone conversation, September 16, 2002.

Paul Urban, Washoe County Water Resources, meeting, August 29, 2002.